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**BELLCOMM, INC.**  
955 L'ENFANT PLAZA NORTH, S.W. WASHINGTON, D.C. 20024

**SUBJECT:** Trip Report - Space Station  
Power Systems Workshop  
Case 620

**DATE:** November 8, 1968  
**FROM:** B. W. Moss

ABSTRACT

A joint Industry/NASA Power System Workshop was held October 20-23, 1968, at Big Meadows Lodge, Va. Participating were representatives of NASA (OMSF, OART, GSFC, MSFC, MSC, LRC, LaRC, ERC, JPL) and Industry (Boeing, EOS, GE, Hughes, LMSC, Martin, MDC, NAR, Philco-Ford, RCA, TRW). Much of the discussion revolved on the interaction of control systems and flexible structures.

A proceedings will be issued by OART as soon as manuscripts are available from the panelists.

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(NASA-CR-100302) TRIP REPORT - SPACE  
STATION POWER SYSTEMS WORKSHOP (Bellcomm,  
Inc.) 9 P

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MEMORANDUM FOR FILE

A joint Industry/NASA Power Systems Workshop was held October 20-23, 1968, at Big Meadows Lodge, Va. The emphasis was on power system requirements and constraints and on technology readiness for space stations of the mid 1970's.

Much of the discussion revolved on the problems associated with the use of large area solar arrays and the interaction of these and the space station during attitude perturbations and corrective maneuvers. Items of particular interest are:

1. TRW Systems, Redondo Beach, California. (R. Ferrenkopf). TRW is developing a digital program under GSFC sponsorship for handling large flexible structures. This program will handle the interaction of flexible structure (array) and spacecraft during attitude correcting maneuvers. Comments indicated the desirability of a formal conference on this subject alone.
2. JPL, Pasadena, California. (Peter Likins). He feels that thermal excitation of a flexible structure and the interaction of it with the vehicle control system is not readily handled by available analytical methods.
3. GE, Valley Forge, Pa. (Hugh Raymond). The possibility of momentum storage in flexible structures during corrective maneuvers may make it necessary to inhibit control system action during these maneuvers to avoid structural damage. Hardware is available, new software is needed.
4. North American Rockwell (R. Boudreaux). Solar cells mounted in rocket engine exhaust plume will survive exhaust product impingement if mounted parallel to flow but not perpendicular to flow. The engine used in the tests was a 22# thrust engine with 6 second burn.

5. McDonnell-Douglas, Huntington Beach, California. (C. Shinbrot). They favor the use of rollup arrays mounted in fairings for better utilization of stowage volume or rollup arrays mounted inside the spacecraft. He expressed the opinion that testing of batteries at constant DOD may not provide data capable of being extrapolated to a "real world" situation. The test data provided by NAD, Crane, may not be enough. E. Cohn, NASA-OART, commented that new tests are being set up by battery experts and statisticians which will provide more useful results.
6. TRW, Systems, Redondo Beach, California. (A. Schoenfeld). He suggests using man to optimize system reliability by having him perform in-flight replacement and repair, but would minimize crew participation during critical mission phases by automation. An important improvement required is fast and efficient battery recharge.
7. Electro-optical Systems. (M. Klein). Gulton is working on a 100 AH NiCd battery under LRC sponsorship. Battery will operate at 30-45% DOD with active cooling. Sophisticated charge control methods are required.
8. RCA, Princeton, N. J. (Joel Bacher). They recommend that work be done on batteries to improve charge rate acceptance and charge efficiency, to reduce temperature sensitivity, to improve seals, and to develop circuits for protection against cell reversal.
9. Boeing, Seattle, Wash. (S. Gross). Holding battery temperature in the range of 40-70°F helps improve life, increase efficiency, and reduce "memory" effect. Thermal conductivities of cells and batteries are not known accurately so design of optimum cell geometry is not possible. He suggests that a thermal design specialist rather than a battery expert should postulate the best geometry from a heat-dissipation point of view.
10. McDonnell-Douglas-Astropower, Santa Monica, California. (D. J. Smatko). They have developed micro fuel cells which can be used to indicate presence of oxygen or presence of hydrogen. By mounting one of each in or on a battery, a means exists for accurately determining the state of charge (oxygen) or the onset of cell reversal (hydrogen).

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- 3 -

Many other papers were presented that have not been summarized here. A copy of the agenda is attached. A proceedings will be issued by OART as soon as the manuscripts are made available by the panelists.

*BWM*

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B. W. Moss

Attachment  
Agenda

SPACE STATION POWER SYSTEM WORKSHOP

<u>SESSION</u>	<u>DAY</u>	<u>TIME</u>	<u>MAJOR TOPIC(S)</u>
1	October 20 (Sunday)	8:30-11:00 p.m.	a. Requirements b. Nuclear Power Options c. Scope of Workshop
2	October 21 (Monday)	8:30-12:00 noon	a. Interaction of solar cell array with space station and attitude control system b. Space station attitude control technology
3	October 21	1:30-5:30 p.m.	a. Array Technology b. Orientation drive systems for solar cell array pointing c. Power system maintainability
4	October 21	8:30-10:30 p.m.	a. Power distribution and control b. System considerations
5	October 22 (Tuesday)	8:30-12:00 noon	a. Power Conditioning b. Battery charge control
6	October 22	1:30-5:30 p.m.	a. Rechargeable battery technology b. Need for emergency standby electrochemical power system
7	October 22	8:30-10:30 p.m.	a. System considerations

-2-

<u>SESSION</u>	<u>DAY</u>	<u>TIME</u>	<u>MAJOR TOPIC(S)</u>
8	October 23 (Wednesday)	8:30-12:30 p.m.	a. Panel meeting to complete workshop proceedings

NOTE: Workshop will conclude at 12:30 p.m. on Wednesday, October 23, to permit reasonable travel departure times

SPACE STATION POWER SYSTEM WORKSHOP  
BIG MEADOWS LODGE, SHENANDOAH NATIONAL PARK  
SKYLINE DRIVE, VIRGINIA  
OCTOBER 20-23, 1968

<u>ORGANIZATION</u>	<u>PANELIST</u>	<u>TECHNICAL SPECIALIST</u>
BOEING COMPANY	SIDNEY W. SILVERMAN 206-773-4884	SID GROSS, BATTERY CHARGING ED GOODRICH, MAINTAINABILITY
ELECTRO-OPTICAL SYSTEMS	WALTER R. MENETREY 213-351-2161 or 2151	MARTY KLEIN, BATTERIES
GENERAL ELECTRIC	WILLARD R. BECRAFT 215-962-3100	BOB WANGER, ATTITUDE CONTROL INTERACTIONS MARVIN CLARK, CONFIGURATIONS AND DYNAMICS
HUGHES AIRCRAFT COMPANY	GEORGE WOLFF 213-648-4618	BILL TURNER, DYNAMIC INTERACTION OF FLEXIBLE SOLAR ARRAYS AND ORIENTATION DRIVE
LOCKHEED MISSILE AND SPACE COMPANY	GARY F. TURNER 408-742-3268	LARRY G. CHIDESTER, SYSTEMS CONSIDERATION ROBERT H. KINSEY, BATTERIES, CHARGE CONTROL, BATTERY THERMAL CONTROL
MARTIN MARIETTA CORP.	JOHN H. MARTIN 303-794-5211 x4417	JAY MCGREW, THERMAL CONTROL TOM GLAHN, ATTITUDE CONTROL AND STABILIZATION
McDONNELL DOUGLAS CORP.	A. DUANE TONELLI 213-399-9311 x2900	C. H. SHINBROT, SYSTEMS CONSIDERATIONS D. J. SMATCO, BATTERIES

<u>ORGANIZATION</u>	<u>PANELIST</u>	<u>TECHNICAL SPECIALIST</u>
NORTH AMERICAN ROCKWELL	A. A. NUSSBERGER 213-773-0610	ROD BOUDREAUX, EXHAUSTS PRODUCTS RON C. STARKEY, SYSTEMS AND RELIABILITY JIM GRAY, POWER DISTRIBUTION AND SPACE VEHICLE WIRING
PHILCO-FORD CORPORATION	DUNCAN L. REYNARD 415-326-4350	HOWARD MCKINNY, POWER CONDITIONING AND SYSTEMS CONSIDERATIONS
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TRW SYSTEMS, INC.	ALFRED KRAUSZ 213-535-0341	ROBERT FERRENKOPF, ATTITUDE CONTROL ART SCHOENFELD, POWER CONDITIONING
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NASA/OMSF	THOMAS HAGLER 202-962-1484 RICHARD L. LIVINGSTON 202-962-3315	CARL JANOW, ATTITUDE CONTROL NORMAN J. MAYER, STRUCTURES FRED SCHULLMAN, NUCLEAF POWER SYSTEMS
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ROBERT OLIVER, STRUCTURAL DYNAMICS  
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ROBERT OLIVER, STRUCTURAL DYNAMICS  
GERALD E. FLEISCHER, ATTITUDE CONTROL  
PETER LIKINS, ATTITUDE CONTROL

**BELLCOMM, INC.**

Subject: Trip Report - Space Station Power Systems Workshop - Case 620      From: B. W. Moss

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